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Helical-scan videotape machines use tape transport arrangements which are very different from those of the familiar quadruplex equipment. An example of a system for format C is illustrated on the cover: the article by Urban on page 6 deals with the work which led up to international standardisation of formats B and C.

Editorial

The 200-kHz transmissions

The BBC's LF transmitting station at Droitwich has long been used by many organisations as an accurate frequency reference. The BBC has cooperated with the National Physical Laboratory to provide a monitored and closely controlled carrier frequency.

When the changes in the use of the LF and MF bands took effect on 23 November 1978 the 200-kHz channel, which had hitherto been used for Radio 2, was transferred to Radio 4 UK and, to improve the availability of that service in Scotland, two more transmitting stations were opened (one at Westerglen and one at Burghead), all three stations using the same carrier frequency. Clearly, when that decision was taken, it became necessary to choose whether the accurate frequency reference service would be abandoned (or at least drastically curtailed) or the other transmitters synchronised to Droitwich, thus making the frequency reference service more extensively available. Simply to build two more stations without precise frequency control would have meant that there would be interference with the existing accurate signals from Droitwich in many areas.

The question of the availability of the accurate reference frequency was subordinate to considerations of the quality of programme service available in areas where there would be similar field strengths from two transmitters. Synchronisation was regarded as likely to produce a much more satisfactory result from the ordinary listener's point of view and so that was the option adopted (see Notebook, page 4). The effects on ordinary reception will be mentioned in an article in the next issue of BBC Engineering and will not be considered further here, where our concern is with the stable reference frequency.

The method of synchronisation had to be considered very carefully: the obvious methods generally lead to short-term frequency variations far outside the accepted tolerance. For example, it would be easy to obtain by division a submultiple of the Droitwich carrier and convey it via a telephone line to Westerglen where the appropriate harmonic could be selected and amplified. Such a technique would produce an average frequency at Westerglen which could be made as close to the frequency of Droitwich as desired by considering as long a period as necessary. The phase difference between the two carriers, however, would be relatively poorly defined because of variations in the characteristics of the line conveying the subharmonic and because of noise. The phase instability is

equivalent to short-term frequency variations which are unacceptably large. Furthermore, the system would be dependent on the audio-frequency feed and the failure of the line would involve failure of the Westerglen output or, at least, failure of accurate frequency control.

We can see the problems more clearly by considering an example. A convenient submultiple of 200 kHz, which could be obtained by division by two, seven times, would be 1.5625 kHz. Such a frequency could readily be accepted by a telephone circuit. The circuit will, of course, introduce a phase shift, but that can be ignored as long as it remains constant: let us, however, suppose that the phase shift changes by one degree. The phase of the 200-kHz output, which is derived as the 128th harmonic of the audio-frequency tone, will change by 128 degrees. How does this compare with the phase changes we can expect with a carrier whose frequency tolerance is two parts in 10^{11} ?

The frequency of a carrier at the limit of such a tolerance can differ from the exact frequency by 4×10^{-6} Hz: this corresponds to a phase difference between the actual output and a theoretically perfect one which changes by $4 \times 360 \times 10^{-6}$ degrees per second, or one degree in about eleven and a half minutes. It will therefore take more than a day for a phase drift of 128 degrees to accumulate.

If we are to reach this standard of performance with an arrangement derived from an audio-frequency feed at 1.5625 kHz we must specify that the phase shift introduced by the circuit providing the feed must not change by as much as one degree per day. Circuits of narrow bandwidth are liable to give rise to substantial changes of phase shift, and so to accommodate this stringent requirement we should expect to have to use wideband circuits – if, indeed, we can meet the specification at all.

Noise can also cause disturbance of the apparent phase of the received signal. A rigorous treatment of the subject would be very involved, but the following simple assessment will suffice to give an idea of the order of magnitude of the disturbances likely to be found. One degree before or after the axis-crossing of the received (noise-free) signal, its amplitude relative to its peak amplitude will be the sine of one degree – about 0.0175. A noise component or, for that matter, any interfering waveform of this amplitude can therefore advance or retard the axis-crossing point and thus change the apparent phase by one degree. This corresponds to a signal-to-noise ratio of about 35 dB. Ignoring the uncertainty in the instant of the next axis-crossing, we see that the receiver's information

about the period (and, therefore, the frequency) of the incoming signal can be in error by one part in 180. Such an error exceeds the tolerance by a factor of about 3×10^8 .

The phase errors introduced by the noise are not, of course, cumulative, and the long-term average frequency is correct. Techniques such as the phase-lock loop can therefore be employed to generate a local, substantially noise-free, signal with the same average phase. By averaging over a sufficiently long period the frequency error can be made as small as desired – in principle, at least. With errors which are so large compared with the required tolerance, and with an audio frequency, the averaging time becomes unreasonably long and we turn to the possibility of reducing the errors by improving the signal-to-noise ratio. To obtain a large increase in signal-to-noise ratio we should naturally wish to reduce the bandwidth – and here we run into direct conflict with the requirement for high phase stability. The natural conclusion is that we are approaching the problem in the wrong way: transmission of an audio-frequency tone with the required phase stability over circuits of substantial length is simply not feasible.

Direct reception of Droitwich at Westerglen would require an impossibly elaborate receiving aerial system to pick out a few millivolts per metre from Droitwich in the vicinity of Westerglen's 50-kW output at the same frequency. The greater the distance between Westerglen and the receiving site the easier the receiving aerial problem becomes, but at the same time the difficulties of conveying the received signal to Westerglen with adequate frequency/phase stability become more intractable.

The solution adopted involves using a receiving site where the field-strengths of the signals from Droitwich and Westerglen are comparable. Simple directional aerials make it possible to receive the two signals virtually independently and

the receiver measures the phase of the Westerglen signal relative to that from Droitwich. A digital signal is generated to represent Westerglen's phase error (i.e. Droitwich is accepted as the standard) and the digital code is sent by telephone line to Westerglen where it brings about appropriate adjustments.

The considerations of signal-to-noise ratio mentioned above must, of course, also apply in this case but, because we are dealing with a signal at 200 kHz and not one at 1.5625 kHz, the magnitude of the problem is reduced by a factor of 128 for a given averaging time.

In the absence of correcting signals from the receiving station, Westerglen's carrier frequency is controlled by a rubidium-gas-cell standard similar to the one at Droitwich so that even if the control link fails the inherent stability is high and the phase drift between the two signals is very slow. Consequently, quite long interruptions of the connection can be tolerated and the accumulated phase drift during an overnight break in transmission is not sufficient to require drastic corrective action.

An exactly similar system is used to synchronise Burghead to Westerglen, thus effectively controlling all three carrier frequencies from the reference oscillator at Droitwich.

BBC Engineering:

Production Problems

Production of BBC Engineering has been beset by a number of difficulties which have led to its erratic appearance. We hope that the worst of these problems have now been overcome and that it will be published more regularly in future.

We apologise to our readers and thank them for their forbearance.

Notebook

CARFAX progress

Preparations for the field trial of CARFAX, the road traffic information broadcasting system developed by Research Department, are well in hand. Three of the five transmitters mentioned in our previous issue (*BBC Engineering*, number 112, page 4) are in operation and engineering tests have begun.

A demonstration of CARFAX was sponsored by the Department of Industry at IVR 79 (International Verkehrs Ausstellung) in Hamburg in June. This very large international transport exhibition attracted visitors from all over the world and the CARFAX demonstration was a prominent centre of interest on the British stand.

It is hoped that CARFAX will be demonstrated in Switzerland in the spring of 1980 and plans are in hand for its appearance at an International Seminar on Traffic Information Broadcasting, also in Switzerland, later in the same year.

BBC digital stereo transmission from Moscow

On 28 May a BBC Radio 1 broadcast of a concert by Elton John in Moscow made engineering history. Not only was it the first live stereo relay of a concert from Russia to the United Kingdom but also the method of transmission foreshadowed the time when international exchanges of this sort will, as a matter of course, use digital technology.

The stereo sound signal travelled from Moscow to Broadcasting House, London, in digital form using the BBC technique of near-instantaneous companding. (See *BBC Engineering*, number 109, page 2). Digital transmission links were not available and on this occasion the signal was sent over a television link by way of an INTELSAT satellite.

Most of the UK population lives within range of stereo VHF/FM transmitters whose programme feeds from London also use digital transmission. If, therefore, the analogue interface through the London continuity area is ignored, the stereo signals were in digital form all the way from the concert hall in Moscow to the local transmitter in the UK. Useful experience of this method of transmission was gained for possible future digital systems.

The BBC acknowledges the excellent co-operation given by the British Post Office (External Telecommunications Executive and the Inland Services), the International Telecommunications Satellite Consortium and the USSR PTT and Radio Service.

200-kHz standard frequency transmissions

Since 23 November 1978 the BBC's high-stability transmission from Droitwich has been supplemented by additional transmissions from Westerglen and Burghead in Scotland and the area served is now much larger.

The frequencies of all three transmitters are controlled by rubidium-gas-cell standards supplied by the National Physical Laboratory (NPL). They have a day-to-day carrier-frequency stability of better than 1 part in 10^{11} and their frequency is maintained within ± 2 parts in 10^{11} of nominal, referred to the caesium standard at the NPL.

The phase of the received 200-kHz carrier from Droitwich is monitored continuously at the NPL during the hours of transmission and the values of the mean daily frequency are published in the monthly technical press. They are also available on application to The Director, National Physical Laboratory, Teddington, Middlesex, England. The values are expected to apply, under normal circumstances, equally well to the transmissions from Westerglen and Burghead because of the way they are inter-related.

Research Department Reports

BBC Research Department has recently published the following reports.

- 1979/4 A computer-based mixing and filtering system for digital sound signals.
- 1979/5 Digital Y_2 , ($U \pm V$): further tests.
- 1979/6 Digital recording using hologram arrays: laser-beam deflection and modulation.
- 1979/7 The maximum permissible interchannel crosstalk for imperceptible restriction of stereophonic stage width.
- 1979/8 Narrow-band FM systems for television links: UHF Band V frequency availability.
- 1979/9 A preliminary investigation into the measurement of time and frequency response of listening rooms and control cubicles.

About 35 Research Department Reports are published each year and an annual subscription costs £25.00. Further information and subscription forms are available from: *Research Executive, BBC Research Department, Kingswood Warren, Tadworth, Surrey, England.*

Staff Changes

Head of Studio Capital Projects Department

Duncan Thomas is the new holder of this post, in succession to Pat Leggatt who, as announced in our last issue, is now Head of Engineering Information Department.

Duncan Thomas joined the BBC in Birmingham in 1958 and a year later began a four-year sandwich course in electrical technology at Hendon College of Technology. He was a member of the experimental colour television team at Lime Grove, London, during the engineering tests for a European colour system in 1962 and 1963. He then joined Television Operations and Maintenance at Television Centre where, in 1965, he became Assistant to the Superintendent Engineer, Regions and Outside Broadcasts.

In 1967 he spent six months on secondment to the Columbia Broadcasting System in New York at the time of the rapid conversion of their studios to colour. On his return to the BBC Television Service he was appointed Television Project Engineer and one of his responsibilities was the planning for the conversion of the old Television News studios at Alexandra Palace for use by the BBC department which was set up to make radio and television programmes for the Open University. At the start of the Open University Operation in 1969 he became its Senior Engineer. In 1973 Duncan Thomas was appointed Head of Programme Services and Engineering in Manchester at a time of Regional expansion which led two years later to the move into New Broadcasting House, Manchester. At the beginning of 1979 he returned to London to become Head of Engineering, Television Outside Broadcasts, and last April he took up his present appointment as Head of Studio Capital Projects Department.



Duncan Thomas

CEEFAX

The BBC's teletext service, CEEFAX, continues to develop and in addition to the two different well-established magazines of news and information on BBC-1 and BBC-2, plans are well advanced for the start of a CEEFAX subtitling service. This will provide subtitles at option to the hard-of-hearing on selection of the appropriate CEEFAX page.

In June 1979, Nicholas Tanton (BBC Research Department) presented a paper, 'UK Teletext - Evolution and Potential', at the 20th Annual Chicago Spring Conference (Consumer Electronics) of the IEEE. The paper reviews the development of the UK teletext system and deals with the reasons for the choice of its technical parameters.

Standardisation of Helical-Scan Videotape Formats

C. E. Urban C Eng, FIEE

Studio Capital Projects Department

Summary: The development of a variety of helical-scan videotape machines with performances beginning to compete with the traditional quadruplex standards offered broadcasters the opportunity of worthwhile savings in both capital and revenue costs: the differences between the recording formats, however, threatened to nullify these savings by requiring facilities for many different types of recording.

In 1977 the broadcasters therefore initiated moves towards standardisation. The SMPTE in the USA and the EBU in Europe set up groups to investigate the position and recommend standard specifications. Because of the different television waveforms on the two sides of the Atlantic complete uniformity between the SMPTE's and the EBU's conclusions could not be expected, but the European group took careful note of the Americans' work and ensured that such similarities as could be preserved were, in fact, recommended.

The manufacturers were, of course, involved in the discussions and their willingness to move from their own original characteristics towards generally acceptable ones made a substantial contribution to the speed of progress towards standardisation. On both sides of the Atlantic firm recommendations were made in record time.

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- 2 Classification of new formats
 - 2.1 Non-segmented-field format
 - 2.2 Segmented-field format
- 3 Standardisation in the USA
 - 3.1 Non-segmented-field format
 - 3.2 Segmented-field format
- 4 Standardisation in Europe
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 - 4.2 Segmented-field format
- 5 Performance
- 6 Meaning of standardisation

Appendix: Composition of EBU Specialist Group

1 Introduction

The introduction of video recording on magnetic tape by Ampex in 1956 began a revolution in television production methods and led to the widespread exchange between countries of high-quality recordings of electronically-originated programmes with which we are so familiar today.

The basic format (that of two-inch-wide* tape moving at about 15 inches per second past a four-head drum – hence the term 'quadruplex' – rotating rapidly so as to draw the heads in succession across the width of the tape) remained unchanged for the next twenty years. This very permanence brought great

benefits for the broadcaster. Almost all professional recordings were made to substantially the same format and any of a broadcaster's machines could be used to play any recording. Transfer of programmes from one organisation to another was therefore straightforward. Extracts from old programmes could be easily and conveniently combined with new material without worrying about problems of compatibility.

These advantages brought economies of operation, but the cost of installing and operating a quadruplex videotape machine is by no means negligible. Each machine currently costs around £60,000 (depending on the optional facilities included) and tape costs are in the region of £100 per hour. Full-facility electronic editing requires three machines as well as associated control equipment and is therefore quite an expensive operation. Furthermore, although the quality of the replayed signal is high the degradation is significant: it absorbs a large part of the overall permitted degradation between camera and transmitter. It constitutes a significant limitation to the number of times a signal may be re-recorded – a fact which is important in certain editing and 'effects' procedures.

In 1976 various manufacturers introduced new videotape machines, all claiming a broadcast standard of performance, costing less than the established quadruplex machines, and using less tape. There were obvious economic attractions in reducing the capital and revenue costs but the different manufacturers adopted different ways of achieving these ends and the abandonment of a single format in favour of several would mean that the savings would only be achieved through the loss of the advantages of a single format. There was, in fact, a pressing need for standardisation.

*Tape width and speed were originally specified in inches and for convenience are so described in this article

2 Classification of new formats

There is no fundamental advantage in any particular width of tape, the crucial factor determining tape costs being packing density: in terms of cost, in fact, halving the tape width is for all practical purposes equivalent to halving its speed. A useful guide to the running costs of a videotape machine would be the area of tape used for each second of programme.

One manufacturer had chosen to retain two-inch tape but the others had opted for tape of half that width.

The new machines also used a different arrangement of the recorded video tracks on the tape. The 'traditional' quadruplex format has video tracks which are almost perpendicular to the length of the tape (figure 1) but the new machines record much longer video tracks almost parallel to the tape length by wrapping the tape round the head drum in about a half or a whole helical turn. (This, of course, is the origin of the term 'helical scan'.)

2.1 Non-segmented-field format

With the long track laid down when an almost complete turn about the head drum is used it is possible to record virtually a whole field in one sweep of a single recording head. Some loss between fields is inevitable as the head passes between the point where the tape comes into contact with the drum (point A in figure 2) and that where it parts from it (point B): in practice, however, the duration of the loss can be made less than the field blanking interval. Synchronisation of the head drum with the field rate of the signal being recorded thus permits the designer to arrange that only a predictable and, therefore, replaceable part of the waveform is lost. (The lost part of the waveform is called the vertical interval gap.) It also means that switching between heads during the picture period is unnecessary and thus picture defects associated with differences between head characteristics are avoided.

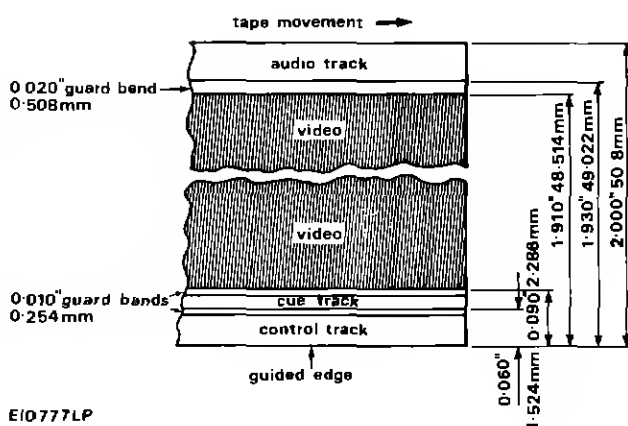
2.2 Segmented-field format

When the tape makes contact with the head drum along about half a turn only, a single head cannot record more than about half the waveform: switching between heads is therefore essential.

Two heads at opposite sides of the drum are used and one field is recorded in three revolutions of the drum: a field thus occupies six successive video tracks. The arrangement of the tape relative to the head drum is shown in figure 3. Machines of this type record shorter video tracks and have smaller head drums than machines using the non-segmented format: this helps to reduce weight and is thus an advantage for portable recorders.

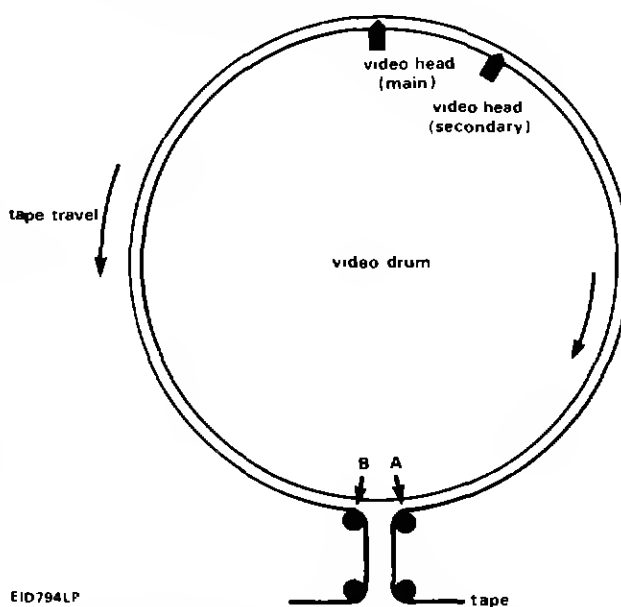
3 Standardisation in the USA

At the SMPTE conference held in San Francisco in January 1977 a 'white paper' was presented jointly by CBS and ABC drawing attention to the urgency of the need for standardisation and calling upon the SMPTE to set up a committee



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Fig. 1 Positions of recorded tracks on traditional two-inch videotape (quadruplex).



E10794LP

Fig. 2 Relationship of tape to head drum for non-segmented-field format helical-scan VTR

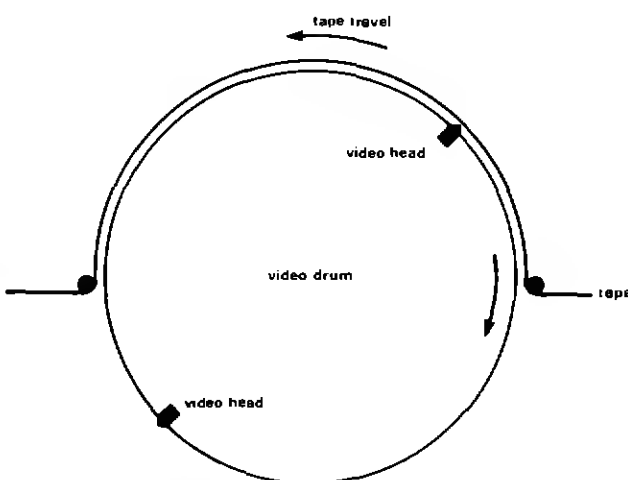


Fig. 3 Relationship of tape to head drum for segmented-field format helical-scan VTR.

to recommend a standard format. The paper started the ball rolling by including a suggested format for non-segmented recording.

Because the segmented and non-segmented types of machine both had their own advantages the SMPTE set up two Working Groups; the one responsible for considering the non-segmented format was chaired by F. Remley, and L.M. Thomas was the chairman of the group charged with recommending a segmented format.

3.1 Non-segmented-field format

The first meeting of the newly-formed Working Group on the non-segmented format was held on 24 February 1977 at the CBS offices in New York. Its first task was to consider the requirements of the prospective users, particularly the American broadcasters.

With the non-segmented-field format it is possible to use only a single recording/replay head on the drum and to reconstruct the synchronising/blanking waveform during the vertical interval gap (see section 2.1). Alternatively, an auxiliary video head may be fitted to the drum specifically to record and replay that part of the waveform missed by the main video head (figure 2). The latter approach was favoured by the American broadcasters, who were unwilling to forgo the ability to use any line of the vertical interval for data and to record these signals on and recover them from tape.

A feature which is standard in professional audio machines but which was unknown in videotape practice is a separate replay head which permits the monitoring of the recorded signal from the tape while recording is in progress. This facility can, in principle, be provided on a non-segmented-field helical-scan machine by an extra head on the drum: an extra *pair* of heads is required, of course, if the sync track is also to be monitored.

During replay all types of videotape machine employ fast-acting high-precision servo systems to ensure that the recorded video tracks pass over the replay head(s). Without such precautions a head would be as likely to be centred on the space between tracks as to follow an individual track.

In their helical-scan machine Ampex introduced a separate pair of replay heads controlled by a servo system capable of moving them over a range of several tracks. This system, known as Auto Scan Tracking (AST), is capable of keeping the replay heads on the recorded tracks while recording is in progress. During replay the heads can follow the tracks at any tape speed from the normal one down to zero. Thus, the AST heads offer not only monitoring during recording but also broadcast-quality slow- and stop-motion without the need for a separate disc machine.

With a third pair of heads another facility can be provided, and it is one which broadcasters find desirable: the insertion of fresh material, such as a scene from another recording, into an existing recorded tape. To make this possible it is necessary to provide a 'flying erase' feature to remove the existing recording between one specified field and another. Thus, a full-facilities machine requires six heads on the drum, in three pairs. One pair is for recording the signal, one pair for replaying it, and one pair for erasing

it in editing procedures.

The simple single-head machine, however, can still play tapes made on full-facilities machines and *vice versa* although, of course, information present on the signal during the vertical interval gap will not be reproduced in such cases. The tips of the heads protruding from the surface of the drum introduce slight distortion of the tape and in order to ensure compatibility between machines with different numbers of heads it is necessary to fit dummy tips in the drums in those positions where active heads are not required.

Other problems which had to be considered were concerned with the longitudinal tracks – for the audio component of the television programme and for control purposes. Some potential users expressed a preference for machines without the separate sync heads, not on grounds of economy but in order to make room on the tape for an extra longitudinal track.

The manufacturers' representatives on the Working Group showed remarkable flexibility in agreeing to modify their formats and working characteristics in order to move towards a common specification. The Working Group was therefore able to make rapid progress and at its meeting on 20th October 1977 agreed a specification, now known as format C, which was forwarded to the SMPTE's Committee on Video Recording and Reproduction Technology. On 7th December 1977 that Committee gave its approval and passed the specification to the SMPTE Standards Committee which also approved the recommendation in the same month. The proposals were published in the March 1978 issue of the SMPTE Journal.

A remarkably short time had been required to reach agreement on such a complicated subject.

3.2 Segmented-field format

The Working Group concerned with the segmented-field format also completed its work quickly. In this case the problem which could have been so intractable with the other format, but wasn't (that of persuading manufacturers to depart from their own preferences) did not arise. Only one organisation was offering segmented-field machines for one-inch tape (Bosch-Fernseh) and their BCN format was, after investigation, assessed as being appropriate for meeting the users' requirements. The format-B specification was therefore based upon it.

4 Standardisation in Europe

At a meeting of the EBU recording committee (Sub-group G2) in June 1977 the need for standardisation of one-inch tape machines was formally recognised by the setting-up of a Specialist Group to consider the problem and make recommendations to G2. The importance of taking account of American practice was also recognised although, of course, complete standardisation with the USA could not be achieved because of the different television line systems. The Specialist Group's first meeting was therefore deferred until September so that the progress of the SMPTE's Working Group could be given full consideration.

4.1 Non-segmented-field format

EID774LP

The first decision to be taken was a difficult one. Previous experience with videotape machines suggested that a writing (head-to-tape) speed of around 30 m/s would be desirable to allow a performance as high as that of the best quadruplex recorders. The result obtained by scaling the American format-C proposals to work on the 625-line 50-field systems in use in Europe was about 21 m/s. The choice, therefore, was between a radical departure from the American format (involving a different drum diameter and different track angle) and a writing speed substantially lower than that preferred. Both alternatives had important disadvantages but the Specialist Group decided that the economic consequences of insisting on mechanically different machines, together with the considerable delay that this would involve, were less acceptable than the lower writing speed. The characteristics obtained by scaling the SMPTE format-C values were therefore recommended.

The views of the European broadcasters differed from those of their American counterparts on the question of the need for recording the whole of the video waveform. Most were content to lose lines 5-15, inclusive, in the recording process, but some wished to have the option of preserving them if required. The Specialist Group therefore concluded that while the three-headed machine could be regarded as normal in Europe, the six-headed version must be allowed as an option. The configuration of the video heads on the six-headed drum is shown in figure 4. Dummy tips are fitted in positions where active heads are not required.

The three-headed drum leaves blank that part of the tape allocated to the sync tracks, thus affording an opportunity to add an extra longitudinal track. A third option is therefore available (see figure 5) using this area for a fourth audio track. It is proposed that dubbing should be possible between this track and audio tracks 1 and 2 (which can be used independently of each other or as a stereo pair).

Option III posed another problem for the manufacturers:

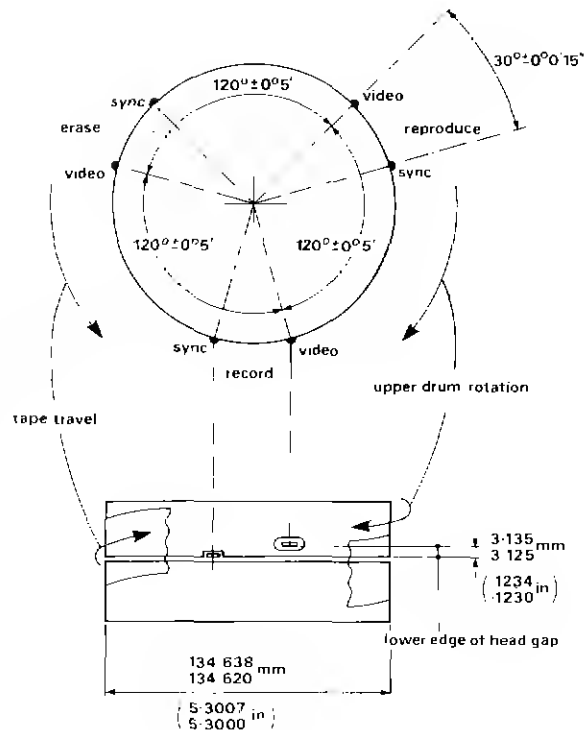
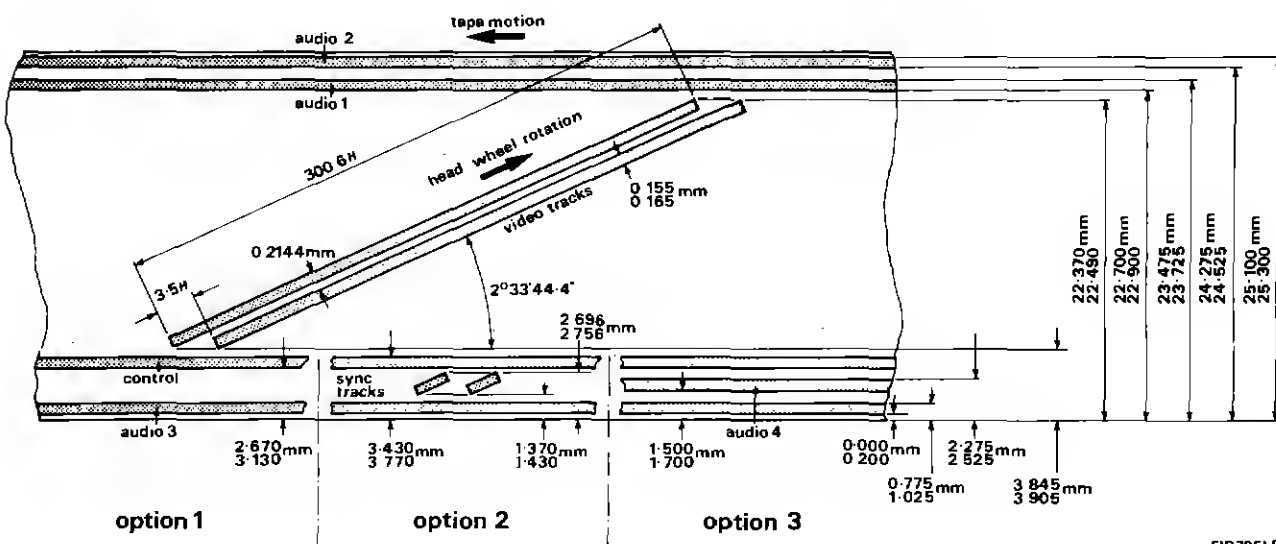


Fig. 4 Video head drum for format C.

the proximity of the fourth audio track to the control track meant that it would suffer unacceptable cross-talk if the then normal practice of saturation recording were used for the control track. Agreement was reached on the use of AC bias for the track. The agreed control signal is capable of distinguishing odd and even fields and of identifying the PAL eight-field sequence.



EID795LP

Fig. 5 Positions of recorded tracks in the three options of format C.

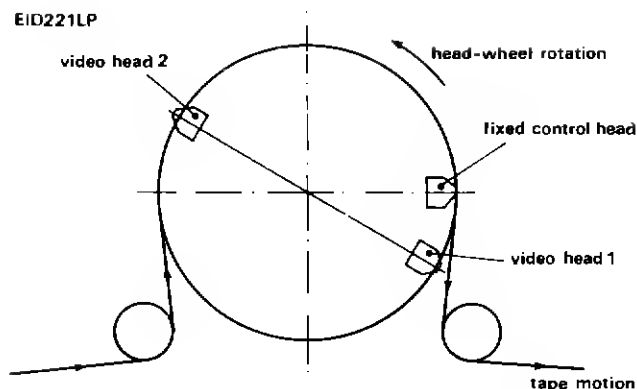


Fig. 6 Video head drum and fixed control head for format B

The video modulation parameters proposed by two manufacturers were different but the organisations concerned were constructive in their approach and one system was agreed with a minimum of fuss.

The deliberations of the European team seeking standardisation were as speedy as those of the SMPTE Working Group and agreement was reached on the European version of format C after only five two-day meetings. In both cases the ready co-operation of the major manufacturers was an important factor in producing this result. They accepted substantial re-tooling costs in the interests of reaching early agreement.

4.2 Segmented-field format

Here, as in America, there was only one contender for the format and the Bosch-Fernseh BCN 625-line version was adopted as the basis of the format B specification. The scanning configuration is shown in figure 6 and the positions of the recorded tracks in figure 7.

5 Performance

It is of interest to compare the performance of the traditional quadruplex machine with what can be achieved by helical-scan recorders. The figures given cannot, of course, be regarded as absolute, but are representative of current machines. Bearing in mind that the helical-scan recorder uses slightly less than one third of the quantity of tape that passes through a quadruplex machine, the differences are remarkably small.

The table shows that the audio signal/noise ratio is better with helical-scan than with quadruplex machines. The reason for this is that the grain orientation in the tape for quadruplex operation favours the transverse video tracks, whereas tape for helical-scan recording is produced with longitudinal (or nearly so) tracks in mind. Furthermore,

format C is immune to the head-switching effects which can at times spoil the output of a quadruplex machine by revealing the boundaries between the groups of sixteen lines recorded on individual video tracks. It is very difficult to quantify the degradation introduced by this fault.

There are, of course, significant ways in which helical-scan performance falls short of that of quadruplex machines. These include noise in the chrominance channel and liability to drop-outs.

6 Meaning of standardisation

The recommendation of a format by the EBU (or, for that matter, the SMPTE) does not, of course, mean the recommendation of particular machines conforming to the specification or even the recommendation that the format itself is necessarily adequate for all broadcast purposes. It is, rather, a recognition that formats of these types *will* be used for broadcasting and an attempt to facilitate the exchange of programmes between organisations and to reduce the overall cost.

Appendix

Composition of EBU Specialist Group

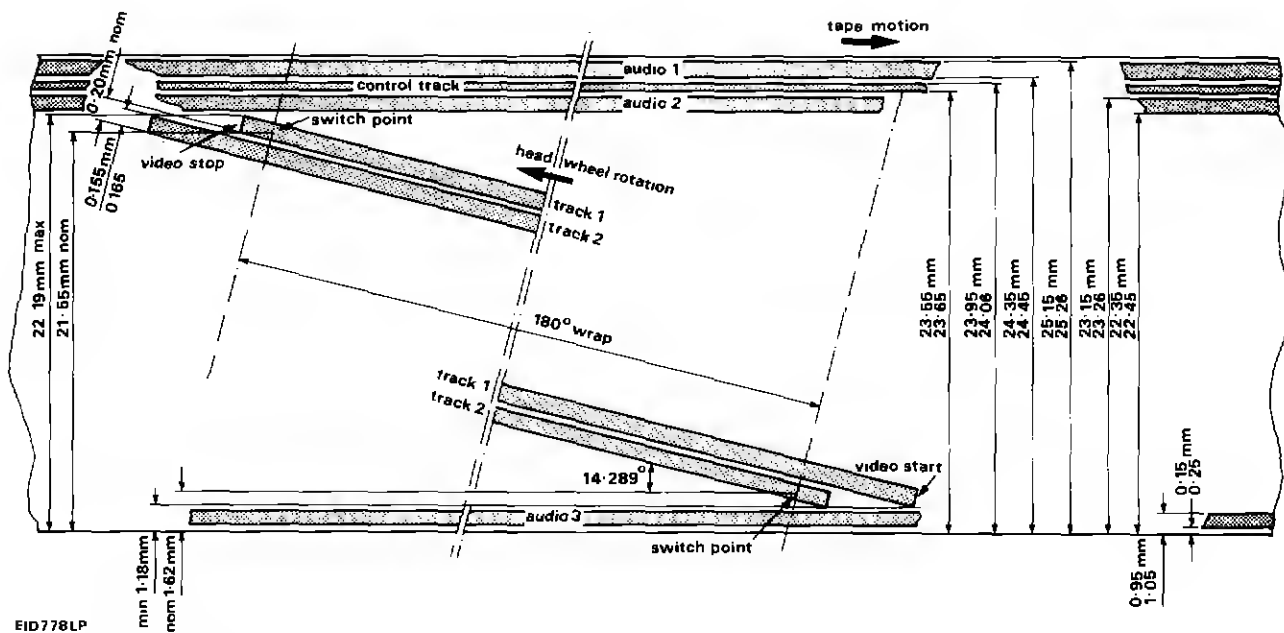
The Specialist Group naturally called for the views of all the member organisations and took into account all the preferences expressed, but the Group consisted of representatives from the following broadcasters:

BBC (Chairman and Secretary)
LWT (UK)
TDF (France)
DR (Denmark)
RAI (Italy)
CBS (USA)
JRT (Yugoslavia)

and from the following manufacturers:

Ampex
Bosch-Fernseh
Marconi
Pye
RCA
Sony
Thomson-CSF

Mr. F. Remley from Michigan University (chairman of the SMPTE Working Group on the non-segmented-field format) also attended the last meeting of the Specialist Group.



EID778LP

Fig. 7 Positions of recorded tracks in format B

	Quadruplex	Format B	Format C
Video			
K-factor	1%	1.5%	1%
Signal/noise ratio	43 dB (6 MHz)	43 dB (5 MHz)	43 dB (6 MHz)
Linearity	2%	2%	2%
Differential gain	4%	4%	4%
Differential phase	4%	4%	4%
Moiré	36 dB	35 dB	35 dB
Audio			
Bandwidth	50 Hz-15 kHz	40 Hz-14 kHz	50 Hz-15 kHz
Signal/noise ratio	53 dB	55 dB	56 dB
Harmonic distortion	3%	3%	3%
Wow and flutter	0.1%	0.1%	0.1%

Facilities for Visiting Commentators: Programme Operation

E. H. Sheppard

Head of International Unit, Television

Summary: It is normal practice for events of interest to the television audience in many countries to be covered by the cameras of a single broadcasting organisation: the associated commentary, however, is rarely internationally acceptable. Individual commentaries are given by commentators from each country taking the programme so that full weight can be given to the particular interests of that country and, of course, to its language.

A new Mobile International Control Room – MICR 1 – has been designed to provide for up to twenty visiting commentators (and their assistants) on site at an Outside Broadcast. The vehicle and the associated commentators' units bring up to date the equipment which the BBC uses for such purposes and, by means of facilities not available elsewhere, help to ensure high broadcasting standards and put the visitors at their ease.

Few broadcasters, condemned to commentate on a football match in another country, eat a hearty meal before ascending the scaffolding. High in the roof of the stadium, with a crowd of 100,000 beneath him and twenty minutes to kick-off, the visiting commentator's throat is likely to be very dry indeed. The view may be magnificent, the colour monitor in just the right place, the microphone on a foam cushion next to the can of 'coke'. In theory he should be able to start broadcasting as soon as he gets a steady red light: in practice there's rather more to it than that.

A typical operation

Imagine two commentators at the Cup Final, both from JRT, Yugoslavia. Their mother tongue is Serbo-Croat. One speaks English well; the other has poor English but fluent German. They are one of twenty or so visiting broadcasting teams commentating live to services around the world using the BBC's camera coverage. They can be assured that all the production aspects will have been tightly planned by Alec Weeks, Cup Final executive producer, but they will want to know if there are any team changes, when the team captions will be shown, if there are to be replays from videodisc, etc., etc. So before the match there is a full briefing from Alec Weeks, and lunch, in a nearby conference room. Then there are questions, both ways. Those addressed to the commentators include:

- Will services be using one or two commentators?
- Who wants to hear a guide commentary from the commentator of another service during the match?
- Are there any strong preferences for a lip microphone or a head-and-breast unit? (combined headphones and microphone)

One Yugoslav wants to hear the ZDF (German) commentary on his headphones and they both prefer lip microphones. Circuits from Zagreb have been booked for forty-five minutes before the International Offer begins, and they are asked to be in their commentary positions by then.

Meanwhile in ICR (the International Control Room) at Television Centre and at the EBU Technical Centre in Brussels the international vision and sound circuits are being established, making sure that the commentators and their countries both see the same picture (not always easy with videodisc) and that the sound of the match (International Sound) from Wembley gets everywhere. At each destination it will be combined with the right commentary relayed from Wembley via international telephone circuits.

The JRT commentators will have eaten a conservative lunch, refused a second glass of wine, and learnt the team changes by heart. They brave the scrum of red-and-white scarves, refuse offers of £50 for their passes, shake a hand or two and take the lift to the commentators' gantry.

At each commentary position is the heart of the broadcast operation; the commentator's unit or box. Its job is to provide the commentators with a choice of sound sources for their headphones, and microphone selection for broadcasting or for speaking on a control line; this usually has call facilities to the associated vehicle at the venue and to the destination. For peace of mind there should be a ready indication to the commentator of just what he has selected, with call lights, transmission lights, etc. It should also be possible to plug in a tape recorder or an interview microphone and to allow the commentator to hear both himself and his colleague on headphones.

The JRT commentators at the Cup Final want to be

able to hear their producer, who is in Zagreb, the International Sound, which is to be mixed with their commentary in the Zagreb studio, and the BBC commentary for information about who scored a controversial goal. In addition, one wants the voice of the ZDF commentator for a guide in German and they both want to hear each other on their headphones, because when the cheer goes up for a goal, lip-reading is the only alternative!

These are typical options to which every commentator is entitled and which the new BBC Mobile International Control Room, MICR 1, and its associated commentators' units aim to provide.

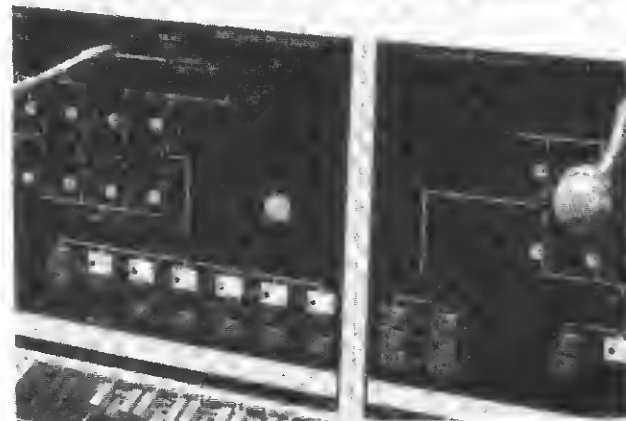
The role of MICR 1

Around the world there are more than a dozen different designs of similar facilities, the most widespread of which is the 'DOZ box' designed by a German consortium and made in large numbers for the 1970 World Cup and 1972 Olympic Games at Munich. The existing BBC units, designed in the early sixties, have stood up well over the years but new techniques, both in production and engineering terms, have meant that the two Foreign Commentary Vehicles (FCVs) and their associated equipment are no longer up to the standards that the BBC sets itself for either domestic or international operations.

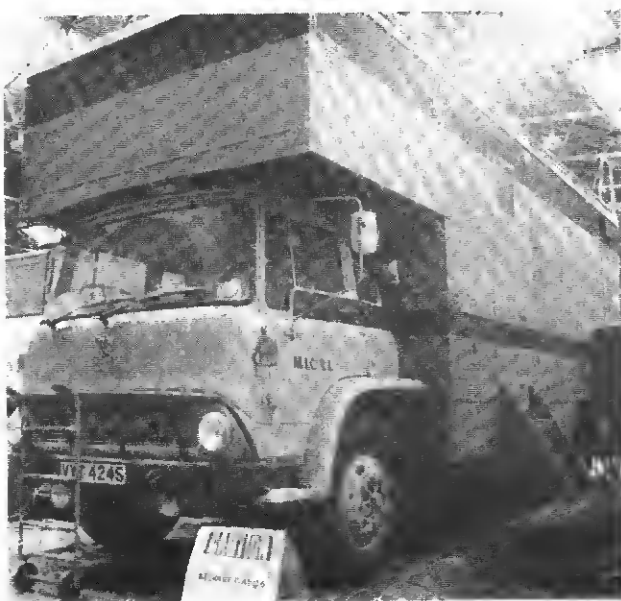
Faced with the need for replacement and having considered various options, the BBC decided to engineer a new mobile control room to an entirely new standard for the eighties with facilities for up to twenty international commentary teams.

As a first step we resolved that a visiting commentator should not be subject to pressures brought about by any limitation of facilities provided by the BBC, and secondly we aimed to present the widest possible variety of options in a way that both the experienced and the occasional broadcaster could quickly assimilate.

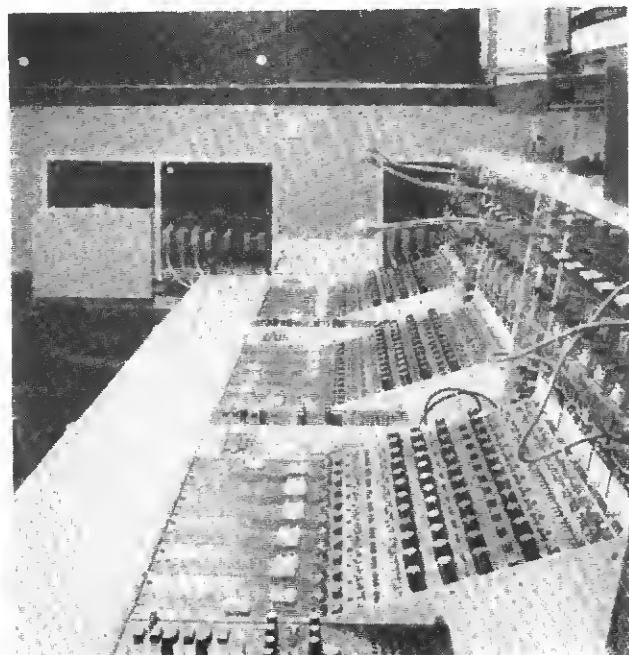
We felt that most of the equipment in use elsewhere had two



The operational area of MICR 1 viewed from the front (above) and back (below). One engineering desk and one production desk had been removed when these photographs were taken.



MICR 1 at base.



particular drawbacks: it did not allow the commentator to listen to two – or more – incoming sources at once, nor to switch between them without having to readjust volume each time. This meant that for the new design rotary source selection was out, and individual volume controls were in. With the new commentators' units the key facility for each commentator is a choice of up to five incoming sound sources, each to the left ear, the right ear, or both; each independently set for level; and each available on its own or combined with one or more of the others. It sounds quite an earful but in practice it gives enormous flexibility because the selection panel of electronically latched touch switches is clearly labelled and logical.

A three-way key selects the microphone for broadcasting or to the control line, and has a 'cough' or off position in the middle. Ringing facilities to call 'home' (the destination) or 'BBC' (the vehicle) complete the normal operation controls. Every facility has lamp indication and there are also tape recorder/interview microphone inputs.

One major innovation is an optional unit for a visiting producer. Connected to the commentator's unit it permits him to hear his commentators on headphones, to cue them as he thinks fit, and to talk to the destination without interrupting them. It is a godsend to the on-site producer trying to slot into his coverage trailers or commercials run from his own

television centre.

On the output side, we planned to enjoy the benefits of being able to limit peak voice levels for some circumstances, but there was no question of building in automatic gain control. The effect of that is all too often a great wash of crowd noise whenever the commentator stops talking, spoiling the intended mix of commentary with International Sound at the destination.

MICR 1 is deployed according to arrangements made by the International Unit at Television Centre. On site, it is staffed by engineers from Television Outside Broadcasts, Stage Managers from OB Group, who directly assist at the commentary position, and Presentation staff who co-ordinate the operation from the vehicle. Equipment bays are divided into their production and engineering functions, so that all co-ordination on behalf of the BBC producer and between the commentators and their countries is provided by Presentation in radio communication with the Stage Managers, all technical services and support by the OB engineers.

In total some 32 separate facilities are available to each of 20 commentary positions, all somehow routed through seven pairs of wires in lightweight cables. The following article describes, among other things, how this is achieved. Meanwhile back at the Stadium:

'Hello Zagreb, here at Wembley the sun is shining . . .'

Mobile International Control Room – MICR 1

M.F.R. McKee C Eng., MIEE

Studio Capital Projects Department

Summary: A Colour Mobile Control Room (CMCR) provides complete video facilities for television outside broadcasts i.e. cameras, vision mixing, etc., and a comprehensive audio output of effects, commentary, etc. for normal domestic use. If the event is of international interest, additional sound channels are required for anything up to about thirty foreign commentators, all separately controlled and routed to their various countries via cables or satellites.

The Mobile International Control Room (MICR) provides these extra facilities in a self-contained vehicle with accommodation for engineering and presentation personnel. The features of the vehicle include a comprehensive control telephone, talkback, monitoring, cueing, identification, and testing systems in addition to programme mixing and control for twenty commentators (and twenty assistants) together with an International Sound (i.e. clean effects) circuit.

The vehicle can be rapidly connected to the CMCR, other vehicles, and power supplies, so that operations may start as soon as possible. Alternatively, if it should be more convenient, the equipment may be removed from the vehicle and set up in any appropriate accommodation at the site. For simple occasions where few commentators have to be catered for the equipment can be operated by one engineer but for the most complicated events up to four engineers and four production assistants may be required.

- 1 Introduction
- 2 Vehicle
 - 2.1 Accommodation
 - 2.2 Environment
 - 2.3 Services
 - 2.4 Termination panels
 - 2.5 Internal distribution
 - 2.6 Storage
- 3 The sound system
 - 3.1 Equipment
 - 3.1.1 The commentator's control unit
 - 3.1.2 The producer's box
 - 3.1.3 The engineering desk
 - 3.1.4 The production desk
- 4 The video system
- 5 AC and DC power distribution
- 6 Radio talkback
- 7 Conclusion

1 Introduction

Eurovision programme exchanges started on a regular and organised basis in 1954. At first the additional sound channels were set up on an *ad hoc* basis using individual sets of Radio OB equipment for each circuit. The equipment was generally rather old (prewar) and took a long time to set up. Accommodation at site was essential.

The first attempt at producing an equipped vehicle for this

purpose was made by installing about 10 sets of this equipment in an old trailer and providing line and cable termination facilities to simplify rigging and testing. FCV 1 (Foreign Commentary Vehicle) went into service in 1956. A few years later, FCV 2 was equipped on more modern lines to provide for six commentators.

In 1966, in time for the World Cup in England, a complete new design of equipment went into service. Four separate sets, each catering for five commentators, provided facilities for a total of twenty. Each set included a separate control desk for a production assistant (PA) and five commentators' control units to a special design. The equipment was later installed in a redundant vehicle which became FCV 3. Two further sets of this equipment were manufactured in 1970, one set being installed in another redundant vehicle, FCV 4, for use on programmes requiring few commentators, and one being kept for such programmes at sites where suitable accommodation was available.

The arrangement of the equipment in four sets of five channels proved operationally successful but the need to use one of the PA desks even for the simplest functions was irksome. When the time came to plan a replacement for FCV 3, therefore, one of the requirements laid down was that it should be possible to operate from one engineering desk for programmes with few commentators. Further, although extra facilities were required to be built into the engineering desks they should nevertheless remain easily transportable. The opportunity was also taken to adopt a name more in keeping with related parts of the broadcasting chain, such as the

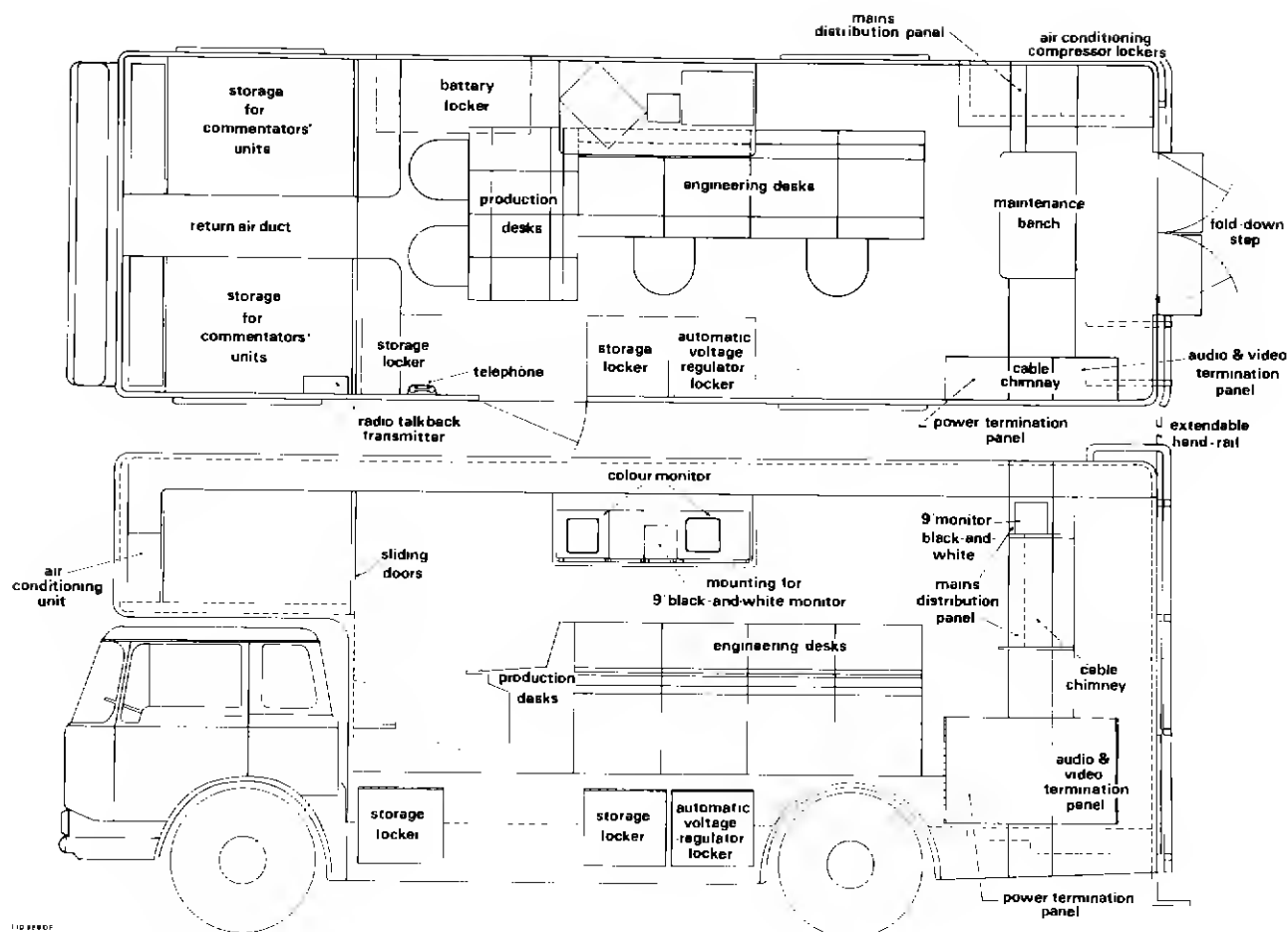


Fig. 1 The Mobile International Control Room – general arrangement.

International Control and Commentary Area (ICCA) at Television Centre, and the new vehicle was termed a Mobile International Control Room, MICR 1.

A complete new system was designed and one set of equipment (i.e. enough for five commentators) was installed in the vehicle in time for the 1978 Wimbledon Tennis Championships, where it was used in conjunction with FCV 3.

2 Vehicle

MICR 1 was the first new vehicle to be used for this particular purpose. Previous units had always been adapted from redundant vehicles. Full advantage was taken of experience with the design and construction of CMCs and of operational experience with FCV 3.

The vehicle was based on a Bedford KGL chassis with coachwork by Freight Development Ltd to a detailed BBC Specification. The overall dimensions are:

Length:	7.7 metres (25' 3")
Width:	2.5 metres (8' 2")
Height:	3.4 metres (11' 3")

The arrangement of the vehicle's contents is shown in figure 1.

2.1 Accommodation

There is accommodation for up to eight operational personnel.

A full house of twenty commentators (each of whom could have an assistant) would normally be covered by two PAs and two engineers, though if the operation were particularly complex four PAs and four engineers might be required.

To allow more space for the staff at events where no more than fifteen destinations need to be served it is usual to remove one of the engineering desks and one of the production desks.

2.2 Environment

Staff will often have to work in the vehicle for long periods. It is therefore provided with considerable thermal and acoustic insulation to make operational conditions as comfortable as possible in most types of weather. It is fully air conditioned.

2.3 Services

A built-in control panel for AC and DC supplies provides comprehensive means of checking, controlling, and isolating any part of the equipment.

2.4 Termination panels

Termination panels on the near side of the vehicle provide all the necessary connections with the commentators' units, other BBC vehicles, electrical power supply, and Post Office

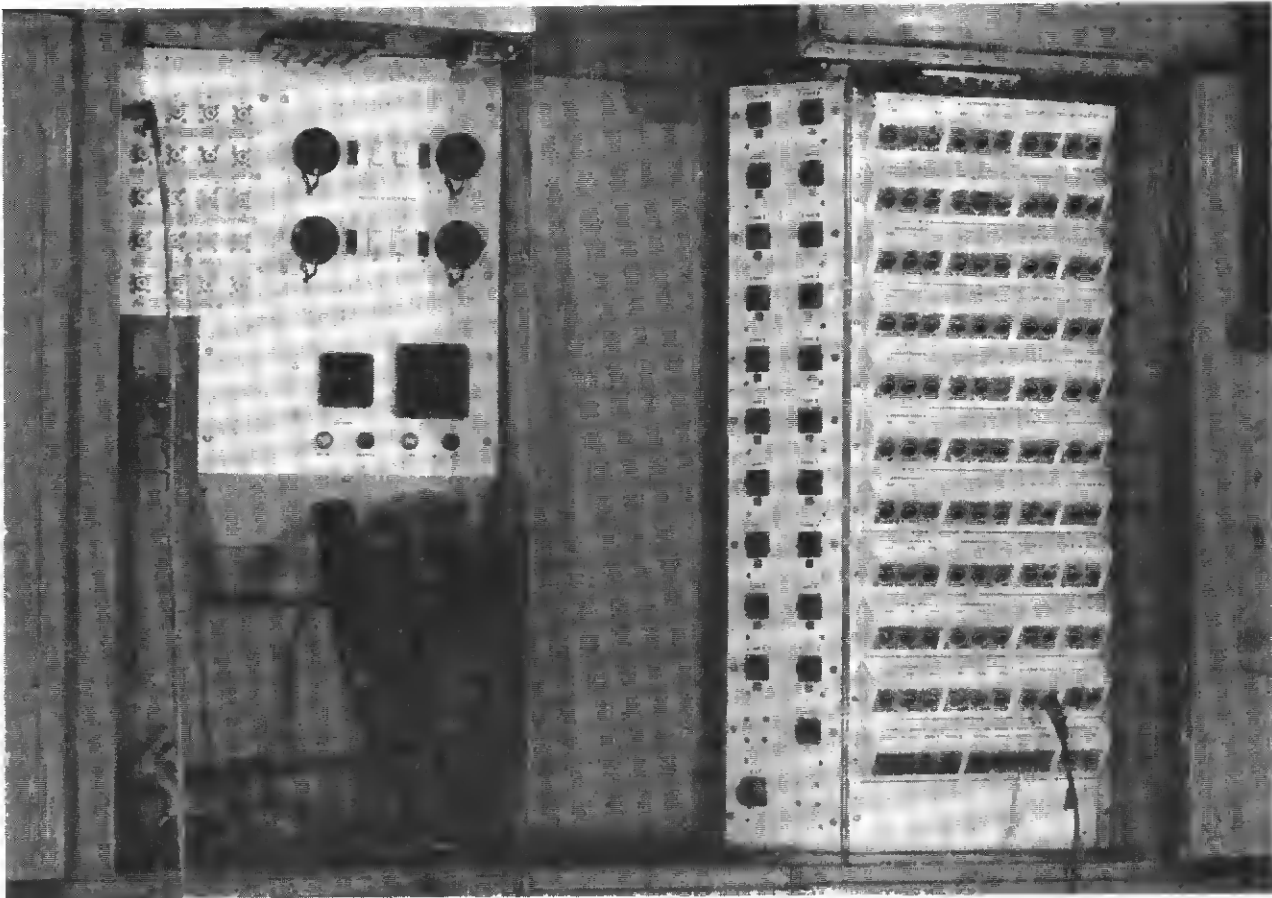


Fig. 2 The termination panels and cable 'chimney'. The doors are normally locked shut after the connections have been made.

lines, using standard connections and cables (figure 2). All external cabling can approach the termination panels from below or above (e.g. first floor window) via a cable 'chimney'. When all the connections have been made, the doors can be locked shut, protecting the panels from the weather and against tampering.

2.5 Internal distribution

Inside the vehicle all technical circuits are routed via a built-in sound and vision bay to facilitate testing and re-routing.

2.6 Storage

To make the vehicle as self-contained as possible, storage space has been allowed for much of the ancillary equipment required for a standard operation. All the twenty commentators' boxes are carried in the Luton head. There are two storage lockers at low level on the nearside of the vehicle but the main storage area is at the rear (figure 3). In addition some commentators' monitors can be carried on the floor.

3 The sound system

The sound equipment to produce the required facilities is very specialised and no BBC or standard commercial equipment existed that would provide the necessary programme mixing,



Fig. 3 The main storage space in the vehicle.

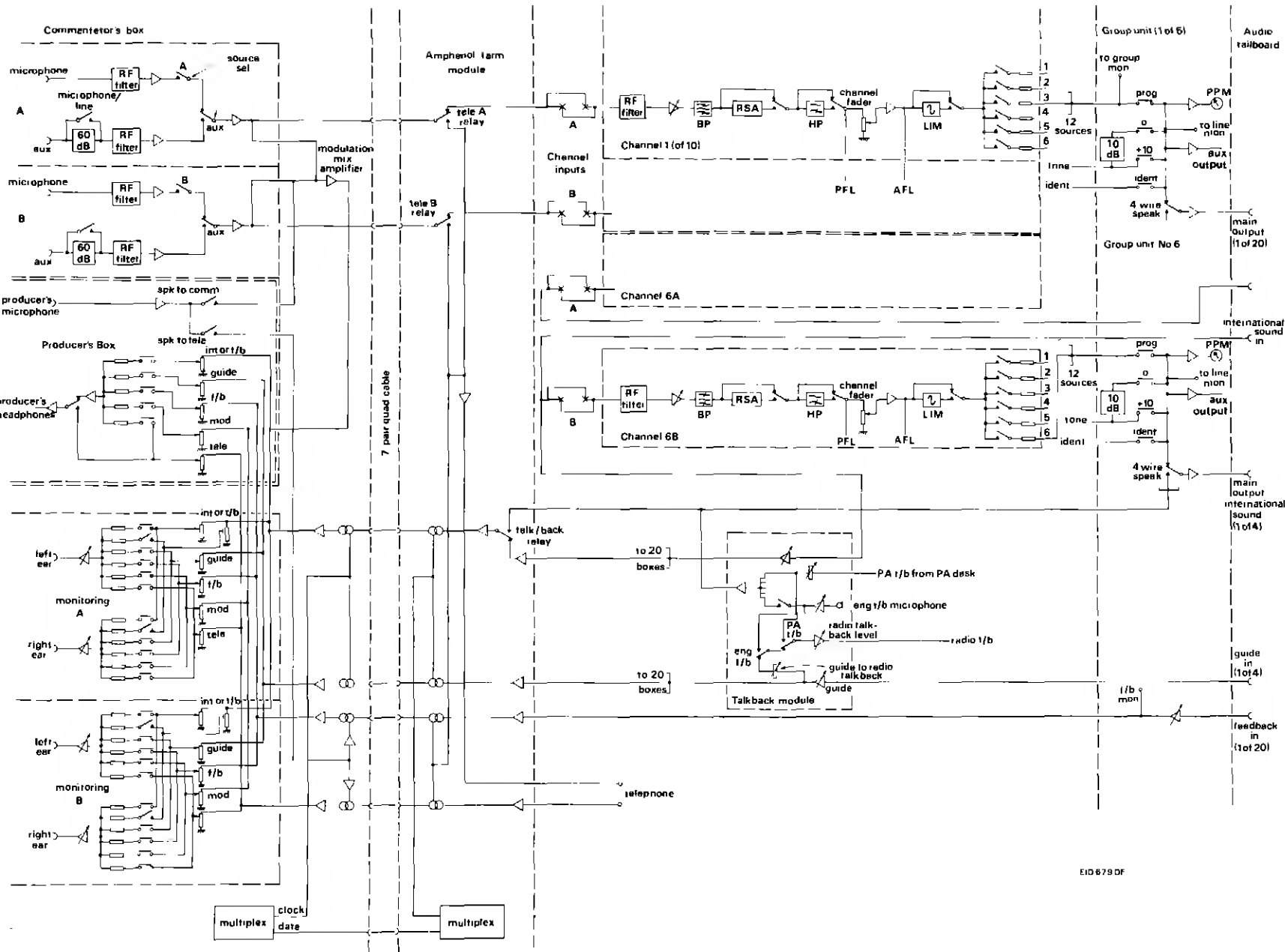


Fig. 4 Interconnections of the principal units of MICR 1.

distribution, and monitoring, together with comprehensive telephone, talkback, and cueing facilities in a compact and easily transportable form.

The equipment was manufactured by Glen Sound Services to a BBC specification and the overall design was the result of detailed co-operation between Glen Sound Services and the BBC Television Presentation, Television Outside Broadcasts, and Capital Projects Departments. Figure 4 is a simplified block diagram.

Although each set of equipment works as a self-contained unit, all external connections were required to be fully compatible with standard Television OB equipment. This requirement also applied to the cable which connects the commentators' boxes to the vehicle which may be up to 1,000 ft (300m) away: it was highly desirable that this cable should be the same as that already used extensively in Television OBs, i.e. a seven-pair microphone cable.

The requirements called for more than seven circuits in this cable. Thus:

Audio circuit

- | | |
|---|-------------------------------------|
| 1 | Microphone A |
| 2 | Microphone B |
| 3 | Telephone Go |
| 4 | Telephone Return |
| 5 | International Sound (clean effects) |
| 6 | Guide sound (BBC sound) |
| 7 | Feedback |
| 8 | Talkback |

Also needed were a 24-V DC supply and many switching circuits for cueing, telephone calling, indicating, and overriding. (A commentator could forget, in the heat of the moment, to carry out an important switching operation. It is possible to 'rescue' him from some of the more likely omissions by overriding the switch setting from the engineering desk).

The seven-pair cable was successfully used by providing the additional audio circuits on phantoms and using a time-division-multiplex method of providing all the switching operations. Cable screens are used for the DC power supplies.

3.1 Equipment

Each of the vehicle's four sets of sound equipment comprises five commentators' control units, one engineering desk, and one production desk. Ten hand-held producers' boxes are provided for sharing between the four sets as required.

These sets of equipment can be used separately or coupled together in pairs or four, depending on the programme requirements. On simple programmes where only one or two commentators are required, it is not necessary to use the production desk because complete control can be effected at the engineering desk.

3.1.1 The commentator's control unit

Figure 5 shows the commentator's control unit or 'box', which is designed for a commentator and his assistant or two commentators feeding the same destination. Each person is provided with cueing, talkback, telephone, and comprehensive monitoring.



Fig. 5 One of the twenty commentators' control units or 'boxes'.

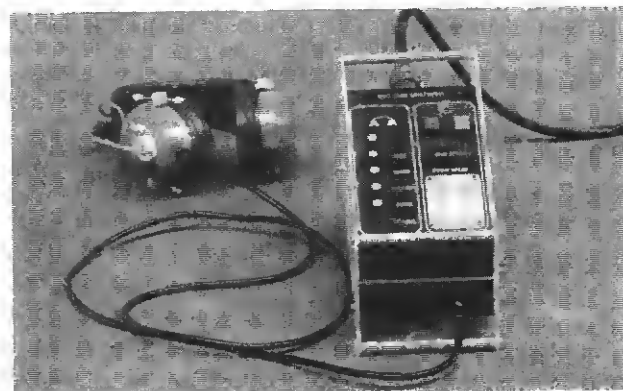


Fig. 6 The producer's box can be connected to a commentator's box when required. There are ten such boxes in MICR 1.

Each person can monitor five sources and can adjust the gain in each circuit independently. He/she can select any one or more of the five to the left ear and has equal freedom of choice for the right ear. The five sources are:

- Telephone
- International Sound (clean effects)
- Guide sound (BBC sound)
- Modulation (a mixture of the output from the producer's box microphone, if any, and the line output from the two parts of the commentator's box)
- Feedback (from destination)

Two microphone connections are available to each person, one for the headset microphone which can be used on programme or telephone, and one for a programme-only microphone. The auxiliary connection will accept a dynamic or condenser microphone and can be switched to accept a high-level signal, such as the output of a tape machine, which can be monitored by switching to 'modulation'.

3.1.2 The producer's box

A small hand-held box is provided for visiting producers (figure 6). It can be connected to any commentator's box by the standard seven-pair cable and has the same monitoring and telephone facilities. A two-way conversation can be held between the producer and commentator.

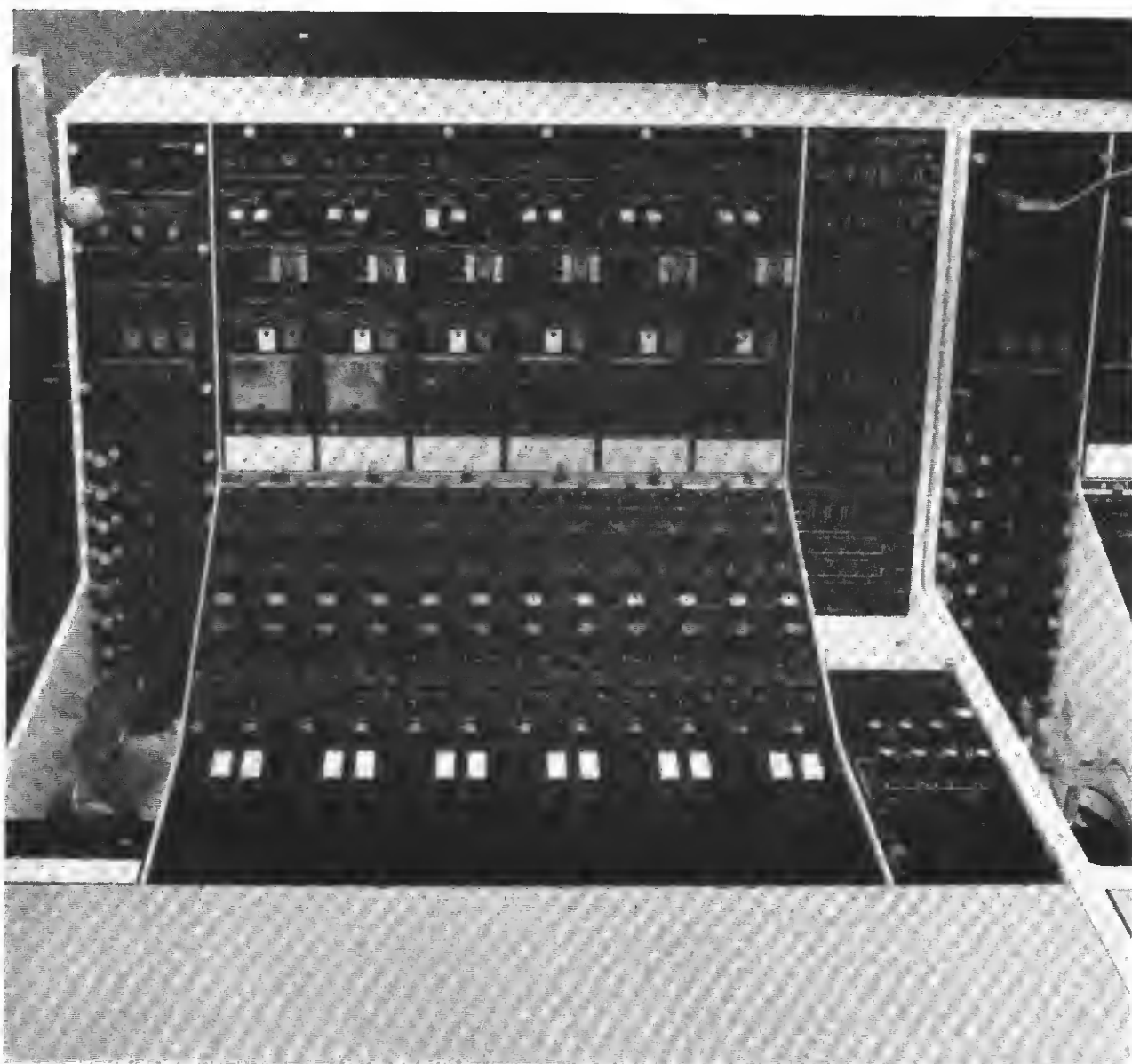


Fig. 7 One of the four engineering desks. Each desk caters for up to five commentators and up to five assistants.

3.1.3 The engineering desk

The engineering desk (figure 7) can be used alone as a twelve-channel, six-output sound mixing desk. It has an integral power unit but requires a separate monitoring loudspeaker.

Each channel will accept an input in the range -85 to $+10\text{dB}$ and is provided with a simple limiter, an LF filter, (for use when there are disturbing low-frequency sounds in the background) and a response selection amplifier. The output of the channel can be routed to any combination of the six outputs of the desk.

Each output can be switched to send to line the channels routed to it, tone at 0 or $+10\text{dB}$, or the output of a cassette replay machine for line identification purposes. Each output is connected to a comprehensive monitoring system and has its own PPM. Associated with each output are a telephone line

and facilities to receive feedback from the destination, talkback to commentator, inject talkback to destination, and signal to commentator, as well as comprehensive monitoring of all circuits.

The first ten channels are normally allocated to commentators (two commentators on each of five boxes), channel no. 11 is spare, and channel no. 12 is used for clean effects (International Sound) which is the main clean feed output from the accompanying CMC. This International Sound circuit is usually routed separately to all the destination countries where it is mixed with the appropriate commentary as required. Alternatively it can be mixed locally into individual commentary circuits.

3.1.4 The production desk

The production desk (figure 8) enables the PA to gain access to

the telephone, cues, and talkback circuits, and to monitor the outputs from the engineering desk. When two or more engineering desks are used, the coupling for the telephone, talkback, and cue lamps is done through the production desk. When only one engineering desk is used, the production desk is not essential. The desk is fitted with loudspeakers, a desk-mounted talkback microphone, a handset, and a headset. These are all operated through remotely controlled equipment in the engineer's desk.

4 The video system

MICR 1 is concerned with the production of commentaries to accompany a video signal, and not with the video signal itself, which originates in the CMCR. Each commentary must, however, have an appropriate relationship to the scenes which the viewer will be watching when he hears it. It is important, therefore, that the commentator should be able to see the same pictures as the viewer, as well as the event itself. A comprehensive vision monitoring system has been provided in MICR 1 to afford not only this basic requirement but also valuable extra facilities.

The system can accept three video inputs from the CMCR as well as a signal from a local check receiver. Any of these sources can be switched at the engineering desks to the commentators' monitors. The same signal can be fed to all twenty commentators or, if required, four different signals can be routed to four groups of commentators. It is also possible to provide any commentator with up to four monitors with selectable sources.

The vehicle is equipped with separate, independently switched, 13-inch colour monitors for the presentation and engineering staff as well as a smaller test monitor mounted on the bay. A test-signal generator is permanently connected via the check receiver circuit.

One of the video circuits from the CMCR can be connected to give access to all the video preview circuits on the matrix in the CMCR. By this means it is possible to let a commentator see, for example, the output of a single camera or a slow-motion replay.

5 AC and DC power distribution

Electrical power is normally connected to the vehicle via an 80-A connector on the termination panel. This is normal practice in CMCRs and similar vehicles. The power can come from either the public supply or a mobile generator. A 15-A connector is also fitted for those occasions when the larger supply is not available. This is sufficient to operate the programme equipment but not the air conditioning, etc.

The power distribution board allows for: selection and metering of supplies, earth fault checking, individual circuit-breaker protection, bypass of the automatic voltage regulator, and the control of heating, ventilation, etc.

In addition to the normal vehicle battery, there is a 24-V technical battery complete with charger. It is used mainly for emergency lighting when the vehicle is not connected to a mains supply or when that supply has failed. The emergency lights are provided for the main operations area, storage areas, steps, and for outside rigging/security purposes. There

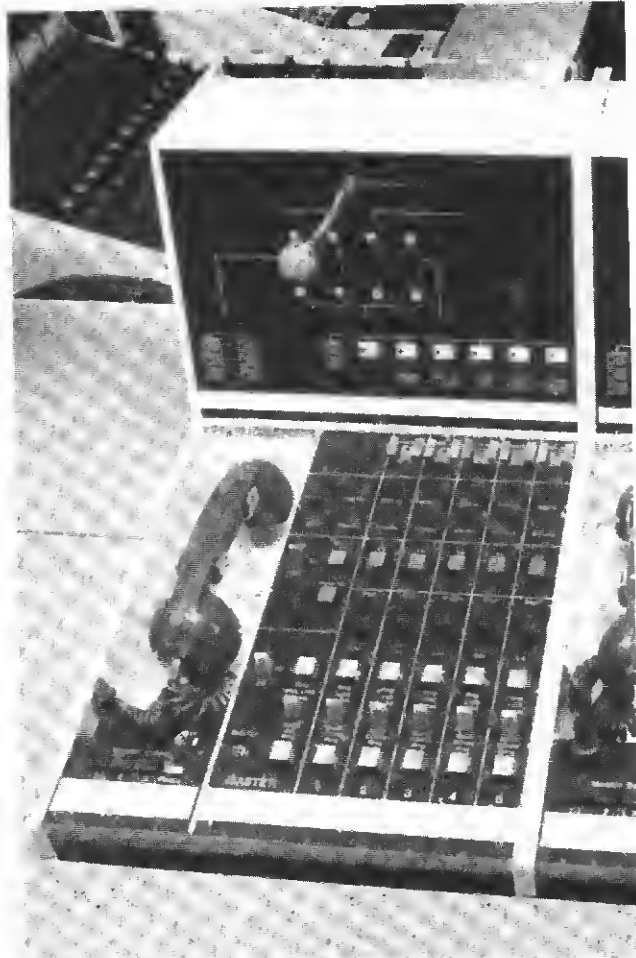


Fig. 8 A production desk. One is associated with each engineering desk but is not necessary when only one engineering desk is used.

is an adjustable timing device to prevent undue strain on the battery when the vehicle is not connected to an external supply.

6 Radio Talkback

A two-way radio talkback system is installed to contact the stage manager(s) who have a roving commission in the area of the commentators to assist and inform them in any way required. The system can also be used to contact roving engineering staff. Access to the radio talkback system can be obtained at the PA and engineering desks and when it is not in use for specific messages it is normally connected to the guide sound circuit to keep the stage managers generally informed.

7 Conclusion

The planning of MICR 1 was aimed at providing a wide range of useful facilities while keeping operation simple for the visiting commentators. It has been highly successful on both scores and has produced excellent results in complex operations. Commentators particularly welcome the versatility of the monitoring system.

It is possible for normally experienced operational staff without extensive special training to produce results with MICR 1 at least as good as those obtainable with earlier equipment. To exploit the full potential of MICR 1, however, requires the staff to re-learn some of their operational techniques. Staff who have had the opportunity of making themselves thoroughly familiar with the equipment have risen to the occasion and become adept in its use. The combination of MICR 1 and practised staff has led to polished operation.

The equipment is not as small and light as would ideally be

wished (because of the wide range of facilities offered and the stringent ruggedness specification required for OB use) so that servicing small-scale operations by taking the necessary items in a small vehicle is not as straightforward as had been hoped, while taking MICR 1 is more expensive than such small operations really warrant. Plans are, however, under consideration for a smaller vehicle with half the capacity of MICR 1. Such a vehicle could deal more economically with the less demanding requirements and could supplement MICR 1 at events requiring up to thirty commentary teams.

Contributors to this issue



M.F.R. ('Mac') McKee joined the BBC in 1941 as a Youth-in-Training at the Lisnagarvey transmitting station. He moved to London as a Technical Assistant in 1943.

In 1949 he transferred to Planning and Installation (later Studio Capital Projects) Department where he has remained ever since. He has been involved in a variety of projects including programme input equipment for transmitters, radio studios, television studios, and outside broadcast vehicles. For a high proportion of the time he has been concerned with television sound installations.



Hugh Sheppard began his BBC career as a Probationary Technical Operator in the Television Service in 1958, after his national service. He was trained as a studio cameraman and worked in that capacity on numerous programmes from *Face to Face* to *Z Cars*.

He joined Presentation as a Production Assistant in 1965 and got his first taste of major international operations with the World Cup in 1966. He became Senior Assistant, Programme Operations in 1972, and was concerned with network, regional, and international operational matters. Such items as the weather forecasts, and the annual campaign against licence evasion were his direct responsibility.

In 1978 he helped to establish the International Unit and this year he became its Head.



Charles Urban has been with the BBC since 1944, apart from a three-year interruption for service with the Royal Signals. After spending his early years in Designs Department, working on both sound and television, he joined Planning and Installation (later Studio Capital Projects) Department in 1959, and was involved in the planning and installation of the videotape area at the Television Centre.

In 1967 he became Head of Television Recording Unit and was appointed Head of Film and Recording Section in 1969. He was Chairman of the EBU Specialist Group which made the recommendations for the new standards described in this issue.

